Oxford Cambridge and RSA

GCE

Chemistry A

Unit **H033/02:** Chemistry in depth

Advanced Subsidiary GCE

Mark Scheme for June 2018

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
___	Underlined words must be present in answer to score a mark
AW	Alternative wording
ORA	Or reverse argument
✓	Correct response
✗	Incorrect response
^	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error

SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore

Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

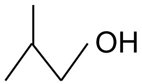
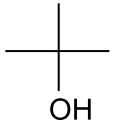
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	Guidance
1	(a)	(i)	$Na(g) \rightarrow Na^+(g) + e^-$ ✓ species (in a correct equation) ✓ state symbols (mark separately)	2	**ALLOW** $Na(g) - e^- \rightarrow Na^+(g)$ **IGNORE** (g) for electron but **CON** any other state
1	(a)	(ii)	electrons (being removed) from same shell ✓ number of protons/nuclear charge increases **AND** electrons more strongly attracted/held more tightly ✓	2	**ALLOW** same/similar shielding Note the **AND** for MP2 (both statements required for this mark) If 'electron' is not specifically mentioned but 'same shell' and 'increasing protons AND greater attraction' given then award 1 mark
1	(b)		$Ra(s) + 2H_2O(l) \rightarrow Ra(OH)_2(aq) + H_2(g)$ ✓	1	**all** state symbols **are** required for this mark
1	(c)		XO_2 **OR** GeO_2 ✓ Si forms SiO_2 **OR** X/Ge has 4 electrons in outer shell **OR** X/Ge will have an oxidation state of (+)4 ✓	2	MP2 can be answered as a comparison of X/Ge with Si **OR** as a statement about X/Ge **ALLOW** for reason 'X/Ge/it has the same number of electrons in the outer shell as Si' **IGNORE** X/Ge and Si are in the same Group and so have similar reactions

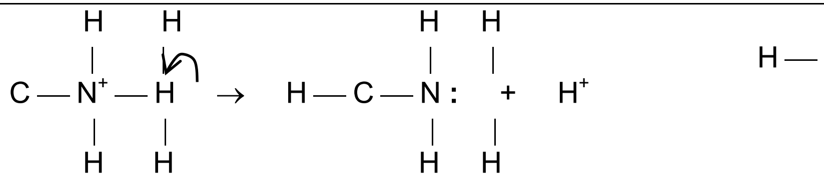
Question			Answer	Marks	Guidance
1	(d)		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5-6 marks)** Learners identify **A** as $Ca(OH)_2$ using a correct volumetric calculation giving a correct reaction equation and providing most of the evidence from the qualitative tests. *The descriptions, explanations and calculations are well-developed, clear and logically structured* **Level 2 (3-4 marks)** Learners identify **A** as $Ca(OH)_2$ using a correct volumetric calculation giving a correct reaction equation but does not support this using the evidence from the qualitative tests **OR** identifies **A** as either an oxide or a hydroxide, giving some support from qualitative evidence, gives a reaction equation and makes some progress in using the volumetric data to work out a value for M_r *The descriptions, explanations and calculations show a sound development, clarity and order* **Level 1 (1-2 marks)** Learners identify **A** as an oxide or hydroxide, with little or no qualitative evidence **OR** gives a reaction equation **OR** makes limited use of the volumetric data *The descriptions, explanations and calculations show a partial development, some clarity and order* **0 marks** No response or no response worthy of credit	6	*Indicative Scientific points include:* **Qualitative tests** • Compound **A** could not be a carbonate • because it is insoluble (in water) • Compound **A** could be an oxide **or** hydroxide • because it is sparingly soluble (in water) • giving an alkaline solution/alkali. • The metal is (more) likely to be near the top of Group 2 because compound **A** is sparingly soluble. **Equation** • $XO + 2HCl \rightarrow XCl_2 + H_2O$ **OR** $X(OH)_2 + 2HCl \rightarrow XCl_2 + 2H_2O$ [or with Ca instead of X] **Volumetric analysis** • works out amount of HCl in 24.80 cm^3 0.0100 mol dm^{-3} (2.48×10^{-4} mol) • works out amount of **A** in 25 cm^3 (1.24×10^{-4} mol) • works out mass of **A** in 25 cm^3 (0.0092 g) [or scales amount **A** up to 250 cm^3 (1.24×10^{-3} g)] • works out M_r of **A** (74.2 or ECF) **Identification of element** • subtracts both 16 and 34 from M_r (58.2 and 40.2 or ECF) • makes suggestion about element in **A** and formula of **A** based on previous answers (eg 40.2 = Ca and $Ca(OH)_2$)

Question			Answer	Marks	Guidance
1	**(e)**		amount $BaCO_3$ = (0.493 / 197.2) = 0.0025 mol volume CO_2 = (0.0025 x 24000) = 60.0 (cm^3) ✓		**ALLOW** 2 or more sf The answer alone scores the mark – the working need not be shown.
			Total	**14**	

Question			Answer	Marks	Guidance
2	(a)		 or  ✓ (for either structure) (2-)methylpropan-1-ol or (2-)methylpropan-2-ol ✓ (for name)	2	Skeletal formula and name are marked separately **IGNORE** wrong dashes, commas **IGNORE** ambiguous attachments unless clearly through H atom, e.g. –HO is a **CON** Initial numbers (in a bracket) are **not required** but any other initial number is a **CON** Other number **is** required.
2	(b)		bond breaking/fission is endothermic/absorbs energy **AND** bond making/fusion is exothermic/releases energy ✓ (in combustion) more energy is (always) released than is absorbed ✓ **ORA** 'the energy released in forming (product) bonds is greater than the energy absorbed in breaking (reactant) bonds' **ORA** scores both marks	2	Statement about bond **breaking AND making** required for MP1 MP2 requires a comparison of energy to be made **IGNORE** a simple reference to number of bonds. **Note** that although the QP states that 'you do not need to refer to specific bonds', IF the correct type AND number of bonds are referred to in the context of MP1 and MP2, these marks may be awarded
2	(c)		$C_4H_9OH + 6O_2 \rightarrow 4CO_2\ 5H_2O$ $C_2H_5OH + 3O_2 \rightarrow 2CO_2\ 3H_2O$ ✓ (for BOTH equations)	1	Both equations are required for the MP **ALLOW** $C_4H_{10}O$ and C_2H_6O as the question does not specify the type of formula and is testing the balancing.
2	(d)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = -7161 (kJ mol^{-1}) award 3 marks** If the answer on the answer line is incorrect then marks can be awarded for the following stages, allowing for ECF (obviously it does not matter whether q or n is calculated first, and the formulae and working need not be shown for the marks to be awarded) $q = cm\Delta T$ $q = (4.18 \times 500 \times 16.0) = 33440$ (J) ✓ n(biofuel) = (1.00/214) = $4.67(29) \times 10^{-3}$ mol ✓ $\Delta_c H = -(1/4.67(29) \times 10^{-3} \times 33440)/1000$ $\Delta_c H = -\ 7161\ (7156)$ (kJ mol^{-1}) ✓	3	$\Delta_c H$ must have the negative sign (7161 by itself scores 2 marks) **ALLOW** 3 (7160), 4 (7156) or more sf, up to calculator value, 7156.16, as sf is not being tested in this question. If the answer on the answer line is incorrect then marks can be awarded for the following stages • Correct calculation of q • Correct calculation of n • Correct evaluation of $\Delta_c H$ using q and n. **ALLOW** ECF

Question			Answer	Marks	Guidance
2	(e)		move can closer to flame **AND** less heat/energy is 'lost'/transferred to the air/more heat/energy is transferred to the water ✓ **OR** use copper/metal can (instead of glass beaker) **AND** copper is a better thermal conductor (than glass) **OR** put a draft shield around apparatus **AND** less heat/energy is 'lost'/transferred to the air/more heat/energy is transferred to the water	1	The explanation **must** be consistent with the suggested modification. **DO NOT ALLOW** 'use a bomb calorimeter' as this is not a 'simple' modification requested in the question. **ALLOW** 'insulate the beaker' **AND** 'less heat/energy lost (from water)'
2	(f)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = +339 (kJ mol^{-1}) award 3 marks** If the answer on the answer line is incorrect then marks can be awarded for the following stages, allowing for ECF. Alternatively, see Guidance column. $\Delta H = \Sigma$ bonds broken – Σ bonds formed ✓ **OR** -677 = [3(C-H) + (C-O) + (O-H) + 1½(O=O)] – [2(C=O) + 4(O-H)] -677 = [3(413) + (C-O) + (464) + 1½(498)] – [2(805) + 4(464)] -677 = [1239 + (C-O) + 464 + 747] – [1610 + 1856] -677 = [2450 + (C-O)] – 3466 ✓ (C-O) = -677 + 3466 - 2450 (C-O) = +339 (kJ mol^{-1}) ✓	3	bond energy <u>**must**</u> have positive sign (339 without + sign scores 2 marks) Alternatively, if the answer on the answer line is incorrect then marks can be awarded for the following stages, allowing for ECF. • Identity **and** number of bonds broken **and** +2450 + (C-O) (kJ mol^{-1}) • Identity **and** number of bonds formed **and** -3466 (kJ mol^{-1}) • -677 = +2450 + (C-O) -3466 (C-O) = +339 (kJ mol^{-1}) A possible mistake will be to overlook the O=O. If so, bond breaking will be +1703, and with ECF, (C-O) = +1086 (2 marks)

Question			Answer	Marks	Guidance
	(g)		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5-6 marks)** Learners identify A (both formulae) and C correctly giving full reasoning from IR **AND** identify D and E correctly, giving full reasoning from the MS. *The description and explanations are well-developed, clear and logically structured* **Level 2 (3-4 marks)** Learners identify A as a primary alcohol, C as a carboxylic acid, D as a (carboxylic) acid and E as ester with some spectroscopic evidence **OR** Learners carry out full analysis of **either** A and C **or** D and E with full evidence. *The description and explanations show a sound development, clarity and order* **Level 1 (1-2 marks)** Learners identify A,C,D and E as alcohol, acid, acid, ester **OR** Learners identify two of A,C,D or E with some spectroscopic evidence. *The description and explanations show a partial development, some clarity and order* **0 marks** No response or no response worthy of credit	6	*Indicative Scientific points include:* **Identification of C and A** • Infrared spectrum of compound **C** has absorptions at 1710cm^{-1} (C=O) and 2980 cm^{-1} broad (O-H). • **C** is a carboxylic acid. • **A** is a primary alcohol, • **A** can be either ... $CH_3CH_2CH_2CH_2OH$/displayed formula **or** $CH_3CH(CH_3)CH_2OH$/displayed formula (ignore names). • The corresponding formulae of **C** are ... $CH_3CH_2CH_2COOH$ **or** $CH_3CH(CH_3)COOH$ (ignore names). *The formulae for A and C must be structural, displayed or skeletal but not molecular as this is given in the question for A* **Identification of D** and **E** • **E** is an (butyl) ester (acid + alcohol) (formed from a carboxylic acid (D) reacting with the 4-carbon alcohol (A)). • M_r value of E is 116 • This is largest *m/z* peak on MS (AW). • **D** is CH_3COOH (116-57(butyl) = 59, CH_3COO). • **E** is $CH_3COOCH_2CH_2CH_2CH_3$ **or** $CH_3COOCH_2CH(CH_3)CH_3$ (ignore names). *Provided A, C and D are structural, displayed or skeletal, and full IR and MS evidence is given, E may be given as $C_6H_{12}O_2$ for L3 (5 marks).*
			Total	18	

Question			Answer	Marks	Guidance
3	(a)	(i)	Br_2 (+ hν) $\rightarrow$ 2Br($\bullet$) ✓	1	**ALLOW** Br_2 (+ hν) $\rightarrow$ Br($\bullet$) + Br($\bullet$) or simply $Br_2 \rightarrow$ 2Br
3	(a)	(ii)	$CH_3\bullet$ (+) Br — Br $\rightarrow$ CH_3 — Br + Br$\bullet$ ✓ correct equation ✓ 'half curly arrows'	2	'full curly arrows' is a **CON** **ALLOW** a variety of half arrows (see Textbook P207 Fig 3 for example)
3	(a)	(iii)	(this method - methanol and hydrogen bromide is preferable, not methane and bromine) bromomethane is the only (organic) product in the reaction of methanol and hydrogen bromide **OR** in the reaction of methane and bromine further substitution/bromination may occur ✓	1	The mark is awarded for the reason, although the choice must be consistent with the reason. **ALLOW** reference to any or all of the correctly named products, (dibromo-, tribromo-, or tetrabromo-)methane for 'further substitution/bromination'. **IGNORE** references to radicals without relating to further substitution. **IGNORE** any references to safety
3	(b)		The student is correct that the C-Cl bond is more polar than the C-Br bond ✓ (However,) bromomethane is a bigger molecule/has more electrons than chloromethane ✓ Therefore bromomethane has greater instantaneous dipole-induced dipole (id-id) intermolecular bonds (imb) ✓ Increase in id-id is greater than decrease in pd-pd ✓	4	**ALLOW** 'Cl is more electronegative than Br' for MP1 MP1 is for recognition of the students' correct statement. MP2 and MP3 are for situation in bromomethane and its effect on id-id imb (ORA for chloromethane). **ALLOW** 'Br has more electrons than Cl' or 'Br is bigger than Cl' for MP2. MP4 is for recognition of greater role of id-id than pd-pd for bromomethane (ORA for chloromethane).
3	(c)	(i)	 ✓ for 'full curly arrow'	1	'half curly arrow' is a **CON**
3	(c)	(ii)	nucleophilic substitution ✓	1	Both words required for the mark
3	(c)	(iii)	amine	1	

Question			Answer	Marks	Guidance
3	(d)	(i)	cloudiness/suspension/precipitation **AND** forming first/in shortest time with iodobutane (and last with chlorobutane) ✓	1	**IGNORE** references to colours of the cloudiness/suspension/precipitation **ALLOW** 'a yellow ppt would form before a white ppt' **DO NOT ALLOW** 'fastest/quickest' for 'first/in shortest time' as this repeats 'fastest' in question
3	(d)	(ii)	ethanol/it is a solvent (for the haloalkane and silver nitrate) ✓	1	**ALLOW** the haloalkane and silver nitrate **OR** reactants can mix if solvent is not explicitly stated.
3	(d)	(iii)	the C–Cl bond in the most polar **ORA** ✓ the C–I bond is the weakest **ORA** ✓ (since the iodoalkane is the most reactive) bond enthalpy is more important (than bond polarity) **ORA** ✓	3	MP1 and MP2 are for statements about bond polarity/bond enthalpy MP1 requires reference to bond polarity not just to electronegativity of Cl MP3 is for the statement of the relative importance of the two
3	(e)		increases the electronic energy ✓	1	**ALLOW** 'increases the energy of the electrons (in the molecule)'
3	(f)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = +285 (kJ mol^{-1}) (correct to 3 sf) award 3 marks** $E = 6.63 \times 10^{-34} \times 7.14 \times 10^{14} \times 6.02 \times 10^{23} \div 1000$ ✓✓ bond enthalpy = +285 (kJ mol^{-1}) **AND** answer correct to 3 s.f. ✓	3	Award 1 out of first two marks if **one** of the following is missing: h, N_A or 1000. Award last mark if an identifiable expression is evaluated to 3 sf (with a plus sign) 285 (without positive sign) scores 2
3	(g)	(i)	0.000021% ozone = 0.000021 parts ozone per 100 parts of air ∴ in 1 part of air there will be 0.00000021 parts ozone ∴ in 1000000 parts of air there will be 0.21 parts ozone 0.21 (ppm) ✓	1	The answer alone, 0.21 (ppm), scores the mark – the working need not be shown.

Question			Answer	Marks	Guidance
3	(g)	(ii)	$O_3 + O \rightarrow 2O_2$ ✓	1	**ALLOW** $O_3 + O \rightarrow O_2 + O_2$
3	(g)	(iii)	Br is not used up in the reaction/Br is reformed (in equation 3.2)/Br is (chemically) unchanged ✓	1	**ALLOW** ‘it’ for ‘Br’ **IGNORE** reference to ‘speeding up the reaction’
3	(g)	(iv)	(it causes) photochemical smog/breathing problems/respiratory problems/lung damage/toxic ✓	1	
			Total	**24**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td></td><td><table><tr><th>Element</th><th>Initial oxidation state</th><th>Final oxidation state</th></tr><tr><td>Mn</td><td>+4</td><td>+2</td></tr><tr><td>I</td><td>-1</td><td>0</td></tr></table>✓ all 4 oxidation states</td><td>1</td><td>+/-MUST be included AND in front of number.</td></tr>
<tr><td>4</td><td>(b)</td><td></td><td>(it) gains electrons ✓</td><td>1</td><td>IGNORE reference to number of electrons gained</td></tr>
<tr><td>4</td><td>(c)</td><td>(i)</td><td>white precipitate(ppt)/solid/suspension ✓</td><td>1</td><td>both colour AND reference to solid are required for the mark but DO NOT ALLOW ‘white AND ppt’ – the white must refer explicitly to the ppt</td></tr>
<tr><td>4</td><td>(c)</td><td>(ii)</td><td>the concentration of chloride ions may be too low ✓
and so a precipitate would not form ✓
OR
the water may contain iodide (ions) ✓
which would give a yellow precipitate ✓
OR
the water may contain bromide (ions) ✓
which would give a cream precipitate ✓</td><td>2</td><td>ALLOW ‘small amount’ for concentration

ALLOW a general comment like ‘there may be other ions/salts/compounds present that would give a precipitate of a different colour’ for 1 mark
Other ions that would give precipitates include:
chromate – red
hydroxide/sulfide – brown/black

The reference must be to the ion, i.e. halide and not halogen.

The second mark depends on the first mark.</td></tr>
</table>

Question			Answer	Marks	Guidance
4	(d)	(i)	$5p^6$ ✓	1	**IGNORE** $5s^25p^6$ or any other more detailed electron configurations
4	(d)	(ii)	add chlorine (water/solution) to (potassium) iodide (solution) ✓ (the mixture/it) would turn brown ✓	2	For MP2 the result must be the observation and not 'iodine would form'. **ALLOW** 'would turn blue/black IF starch has been added.
4	(d)	(iii)	$Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$ ✓	1	**IGNORE** state symbols
4	(d)	(iv)	chlorine is smaller/has a smaller atomic radius/has fewer (electron) shells ✓ the electron gained is held more tightly ✓	2	**ALLOW** 'the outer shell (of electrons) is closer to the nucleus' for MP1 **ALLOW** 'the electron is more readily attracted (and retained)' **IGNORE** simply (electron) gained more easily as there must be some reference to attraction
4	(e)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 78 (%) award 3 marks** If the answer on the answer line is incorrect then marks can be awarded for the following stages, allowing for ECF (the working need not be shown for the marks to be awarded) $n(S_2O_3^{2-}) = (28.40 / 1000 \times 0.200)$ $n(S_2O_3^{2-}) = 5.68 \times 10^{-3}$ (mol) $n(I_2) = (5.68 \times 10^{-3} / 2)$ $n(I_2) = 2.84 \times 10^{-3}$ (mol) ✓ $M_r(I_2) = (126.9 \times 2) = 253.8$ $m(I_2) = 2.84 \times 10^{-3} \times 253.8)$ $m(I_2) = 0.72$ (0.72079) g ✓ % purity = (0.72 / 0.92 x 100) % purity = 78 (%) ✓	3	**ALLOW** final answer to 2 or more sf (calculator answer is 78.34...) Alternatively, using moles, marks can be awarded for the following stages: $n(I_2) = (0.92/253.8) = 3.62 \times 10^{-3}$ (mol) $n(I_2) = (28.40/1000 \times 0.200)/2 = 2.84 \times 10^{-3}$ (mol) % = $(2.84 \times 10^{-3}/3.62 \times 10^{-3} \times 1000) = 78$ (%)
			Total	**14**	

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